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FIRE TEST OF PRECAST, REINFORCED CONCRETE ROOF SLABS

by

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FIRE TEST OF PRECAST, REINFORCED CONCRETE ROOF SLABS

Test Report No. TG10218-23:FP3273
Fire Test 339

1. INTRODUCTION

At the request of the Bureau of Yards and Docks, a roof deck consisting of three precast concrete channel slabs of a special design was subjected to a fire endurance test. This test was a part of a development program of the Bureau of Yards and Docks and was intended to provide data for use in future designs, including prestressed concrete slabs.

2. TEST SPECIMEN

The specimen subjected to test was made up of three identical panels, each of which was in the form of a channel 17 ft 10 in. long, 4 ft 2 1/2 in. wide, 8 in. deep along each side or flange, and 1 1/4 in. thick through the web. Transverse ribs were located one at each end, at each quarter point, and at the center, thereby dividing each panel into four equal bays. The 1 1/4 in. thick web was reinforced at mid-thickness with 2- by 2-in. No. 12 ga welded wire fabric which was carried down each side flange to 3/4 in. from the bottom. Each flange included a single longitudinal 3/4-in. deformed reinforcing bar and each transverse rib, two 1/4-in. deformed round bars.

The concrete was mixed in the proportions of 1 part (by weight) cement, 2 1/2 parts clean Potomac River sand, and 2 parts clean White Marsh gravel. The gravel had been passed through a 3/8-in. sieve. The tests of nine cylindrical samples of the concrete (at the time of the fire test: 10 to 11 months after casting) indicated compressive strengths from 5840 to 7420 lb/in.^{2} averaging 6260 lb/in.^{2} The details of the construction are given in figure 1.

3. TEST METHOD

The three panels were aged under the temperature and humidity conditions in a ventilated occupied work room for 10 to 11 months before test. They were placed to span the long dimension of the test furnace, their edges butted and the joints were filled with grout. During test the bottom sides of the panels were directly exposed to the furnace fires which were controlled to provide average furnace temperatures close to those specified in the Standard Methods of Fire Tests

of Building Construction and Materials, ASTM E119-53 which include: 1000° F at 5 min, 1300° F at 10 min, 1550° F at 30 min, 1700° F at 1 hr, and 1850° F at 2 hr. Temperatures were measured in the furnace chamber, on the reinforcing bars and wire fabric in the concrete, and on the unexposed surface of the panels. Such measurements were made for all three panels but only those for the center panel were considered, in order to eliminate edge effects. The panels were subjected to an applied load of 15.3 lb/ft^2 and the deflections of the center panel were measured.

4. RESULTS

During the fire test, considerable smoke and steam issued from the joints in the test specimen in the first few minutes; at 10 min, the average temperature of the unexposed surface had risen 250 deg F above its initial value; 18 min, hairline cracks in the top surface outlined the bays; 23 min, whole assembly bowing upwards but webs of channels sagging slightly; 27 min, grouted joints between panels open 1/2 to 1 in.; 39 min, craze cracks over top surface; 51 min, cracks in upper surface transverse to flanges and ribs, none over 1/16 in. wide; 1 hr 30 min, no cracks in concrete over 1/8 in. wide; 1 hr 52 min, central panel sagging rapidly, load removed; 2 hr 3 min, gas off.

The fire resistance was limited to 10 min by excessive transmission of heat through the specimen. However, the assembly remained an effective barrier to the penetration of flames for about 25 min and the individual panels remained so throughout the 2 hours. No cracks were observed in the exposed surface during the test but many were obvious after cooling, as shown in the figures. The center panel sagged about 2 ft below its original position at center span, most of this deflection having occurred in the last 10 min of the test after the removal of the applied load. The average temperature of the 3/4-in. reinforcing bars of the center panel reached 1000° F at 1 hr 25 min and the maximum reached 1200° F at 1 hr 47 min. The fire exposure severity for the 2-hr duration was 92.9 percent of standard. Plots of the various temperatures measured are given in figure 2, the deflections at midspan of the center panel during the test in figure 3, the profile of the center panel the day after test in figure 4, and views of the condition of the specimen in figures 5 through 9.

The results of this test indicate a fire endurance limit of about 10 min for the particular specimen tested.

Neither the contents of this report nor the fact that the test was conducted at the National Bureau of Standards may be used in advertising or promotional literature.

FIG. 2 OBSERVED TEMPERATURES,

of Building Construction and Materials, ASTM E119-[illegible], which includes: 1000° F at 5 min, 1300° F at 10 min, 1550° F at 30 min, 1700° F at 1 hr, and 1850° F at 2 hr. Temperatures were measured in the furnace chamber, on the reinforcing bars and wire fabric in the concrete, and on the unexposed surface of the panels. Such measurements were made for all three panels but only those for the center panel were considered, in order to eliminate edge effects. The panels were subjected to an applied load of 25.3 lb/ft² and the deflections of the center panel were measured.

4. RESULTS

During the fire test, considerable sound and steam issued from the joints of the test specimen in the first few minutes; at 10 min, the average temperature of the unexposed surface had risen 250 deg F above the initial value; 16 min, bubbling [illegible] in the unexposed surface continued [illegible] at 23 min, which [illegible] but [illegible] of [illegible] slightly; 27 min, [illegible] joints between panels [illegible] 1/2 to 1 in.; 30 min, [illegible] panels; 41 min, [illegible] in [illegible] surface [illegible] and wide, some over 1/16 in. wide; 1 hr 30 min, no cracks [illegible] over 1/8 in. wide; 1 hr 58 min, central panel sagging rapidly, load removed; 2 hr 1 min, gas off.

The fire endurance was limited to 10 min by excessive transmission of heat through the specimen. However, the assembly remained an effective barrier to the penetration of flames for about [illegible] min and the individual panels remained in place throughout the 2 hours. No cracks were observed in the exposed surface during the test but many were obvious after cooling, as shown in the figures. The center panel sagged about 3 in below the original position at center span, most of this deflection having occurred in the last 15 min of the test after the removal of the applied load. The average temperature of the 1/2-in. reinforcing bars of the center panel reached 1000° F at 1 hr 25 min and the maximum reached 1200° F at 1 hr 47 min. The fire exposure severity for the 2-hr duration was 96.9 percent of standard. Plots of the various temperature measurements are given in figure 2, the deflection at midspan of the center panel during the test in figure 3, the profile of the center panel the day after test in figure 4, and views of the condition of the specimen in figures 5 through 9.

The results of this test indicate a fire endurance limit of about 10 min for the particular specimen tested.

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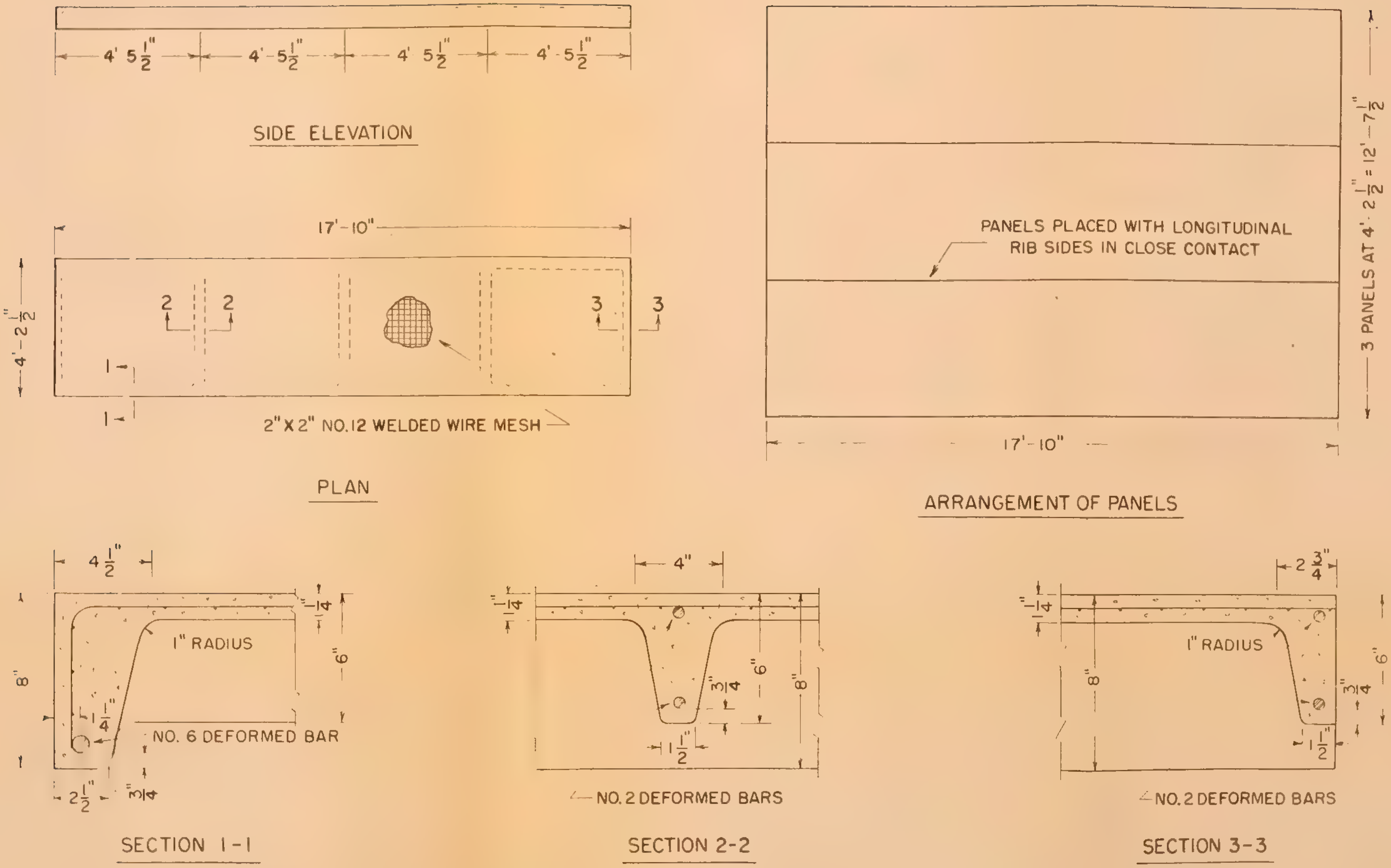

NOTES

CEMENT FACTOR	7 BAGS/CU. YD.	INTERMEDIATE GRADE REINFORCING	24,000 PSI
MAXIMUM SIZE AGGREGATE	3/8 IN.	WIRE MESH	30,000 PSI

FIG. 1 CONSTRUCTION DETAILS OF PRECAST ROOF PANELS

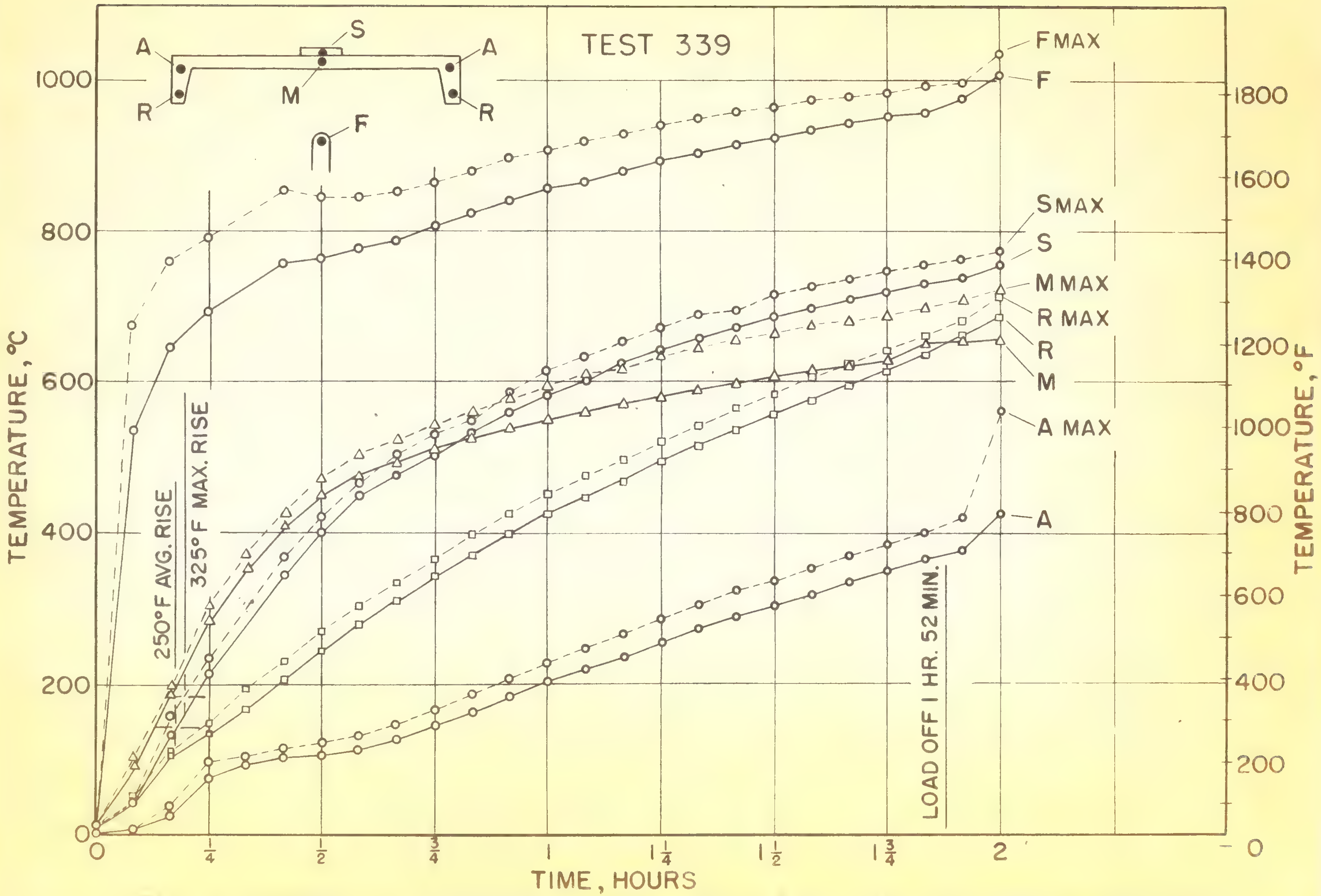

FIG. 2 OBSERVED TEMPERATURES, MAX. AND AVG., CENTER SLAB ONLY

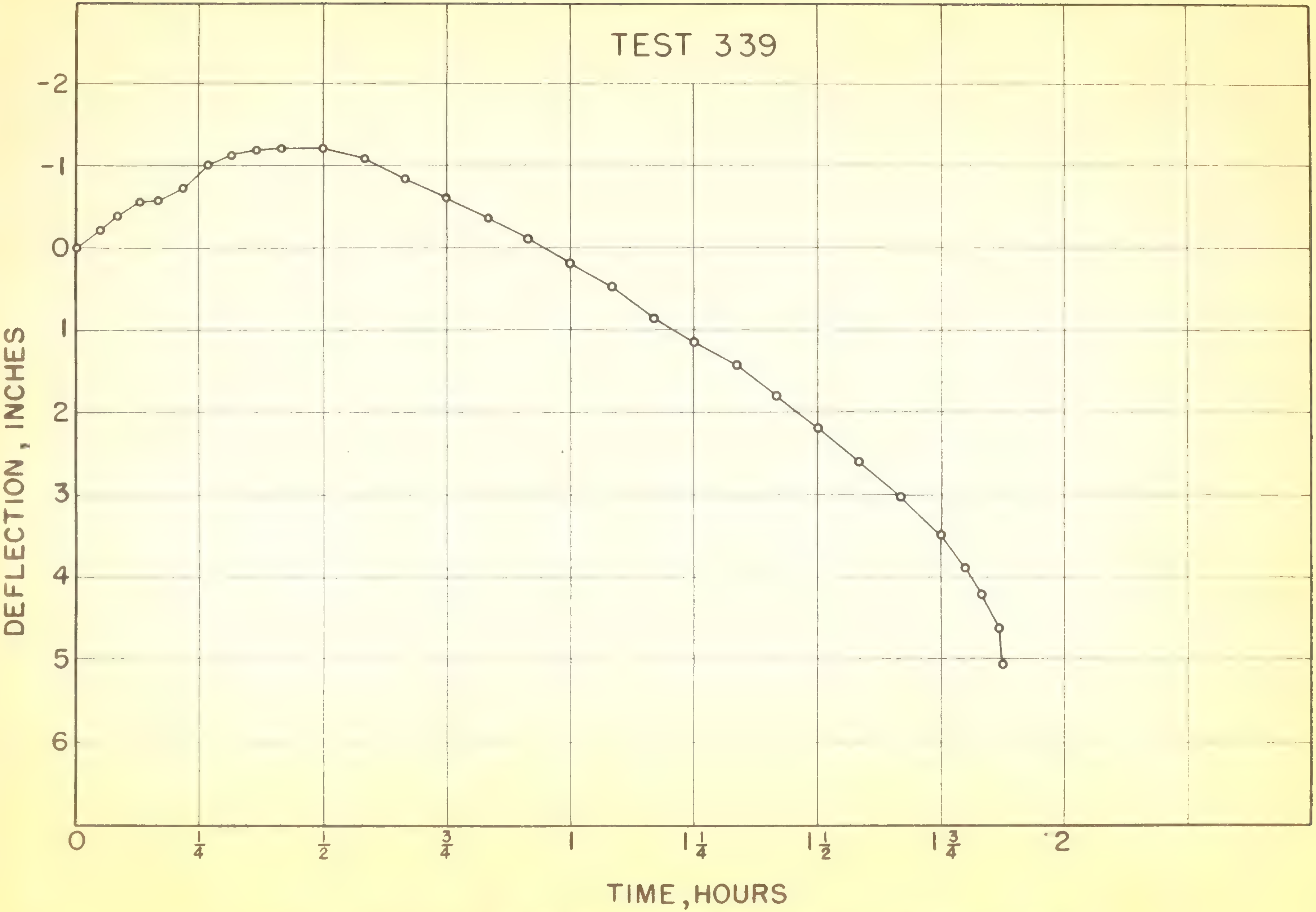

FIG. 3 DEFLECTIONS AT CENTER SPAN VS TIME
NEGATIVE DEFLECTIONS UP, POSITIVE DOWN

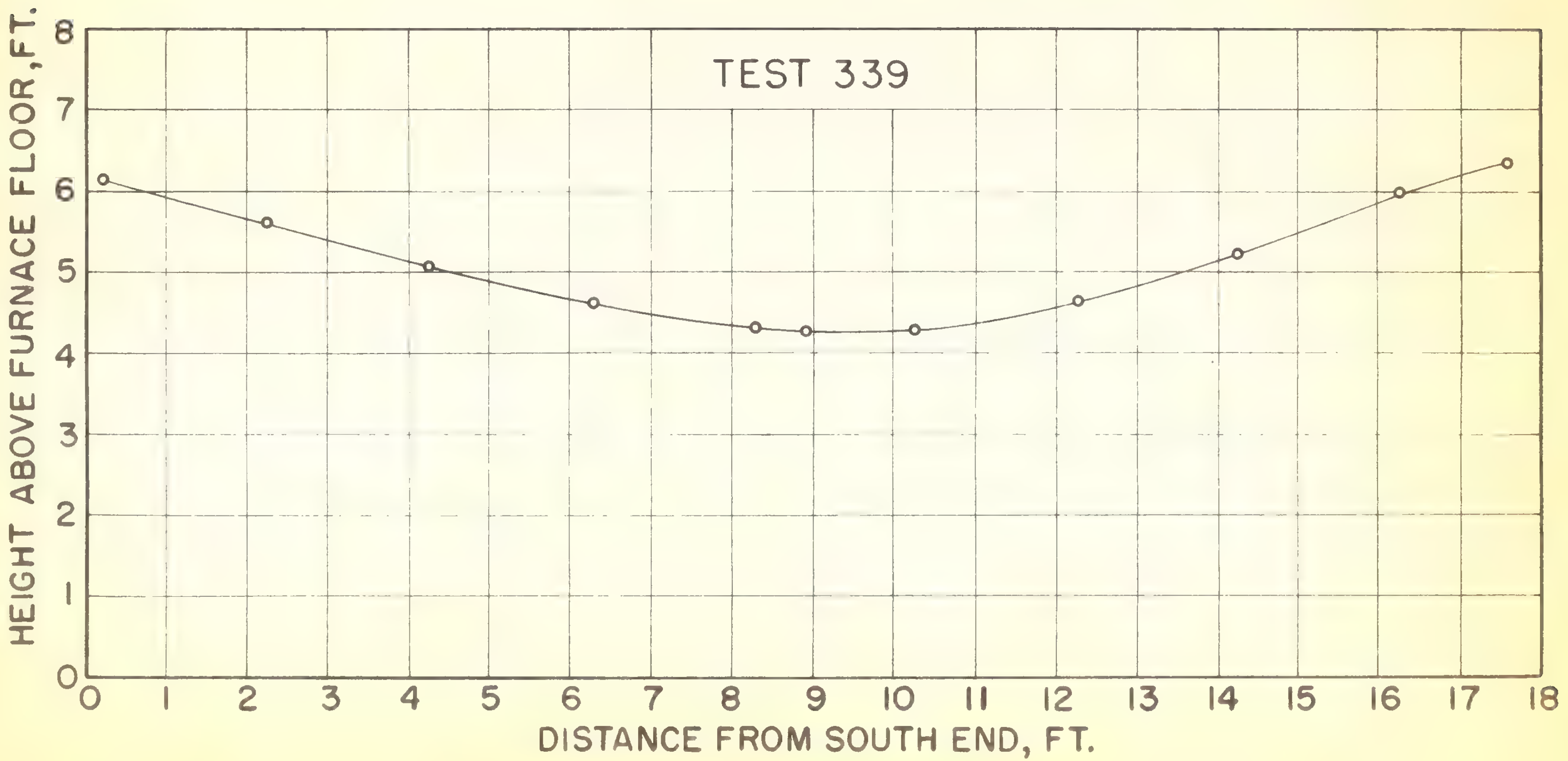

FIG. 4 PROFILE OF WEST FLANGE

MEASURED AFTER COOLING, UNDER PARTIAL LOAD

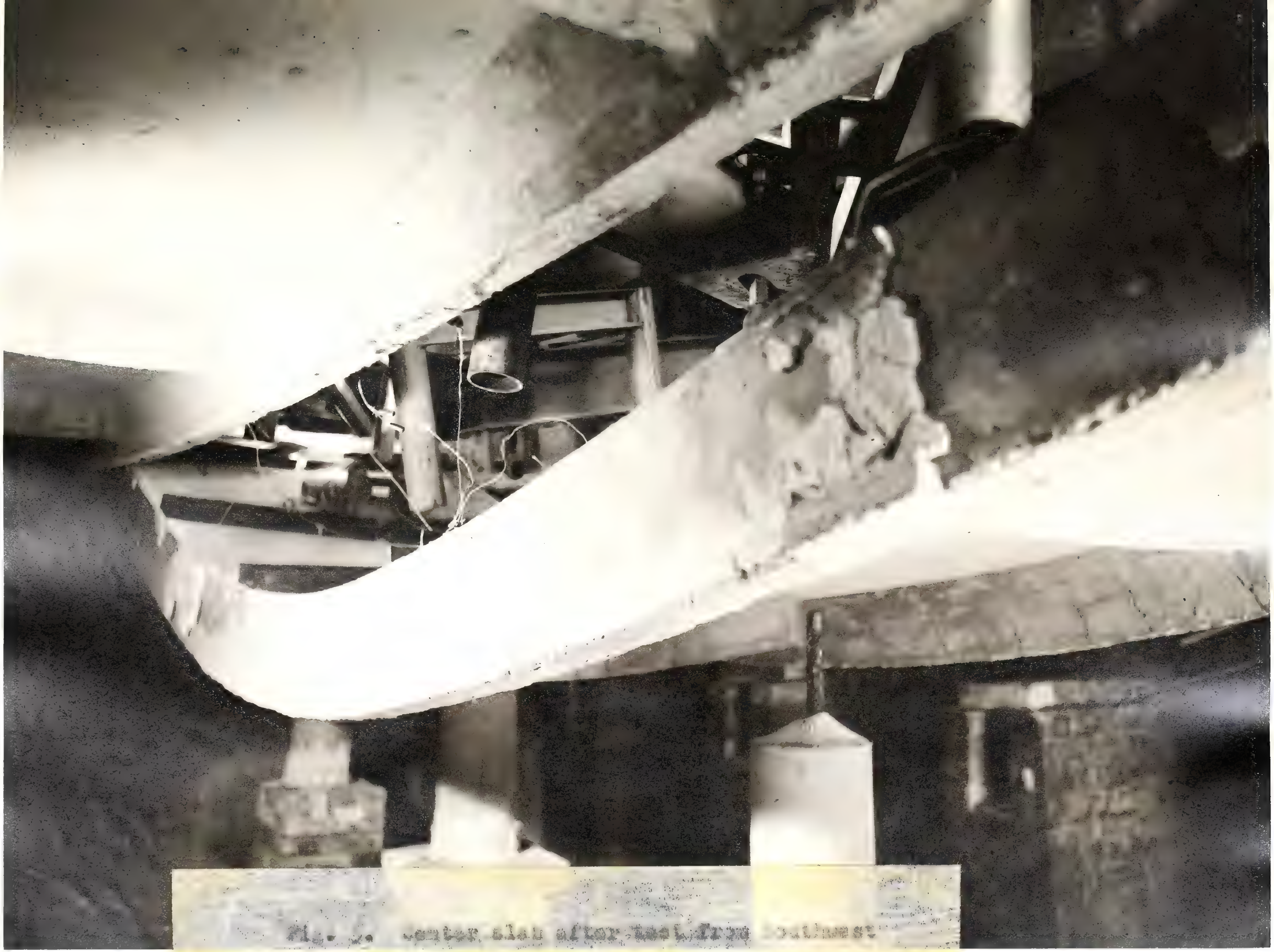

Fig. 9. Center slab after test, from southwest

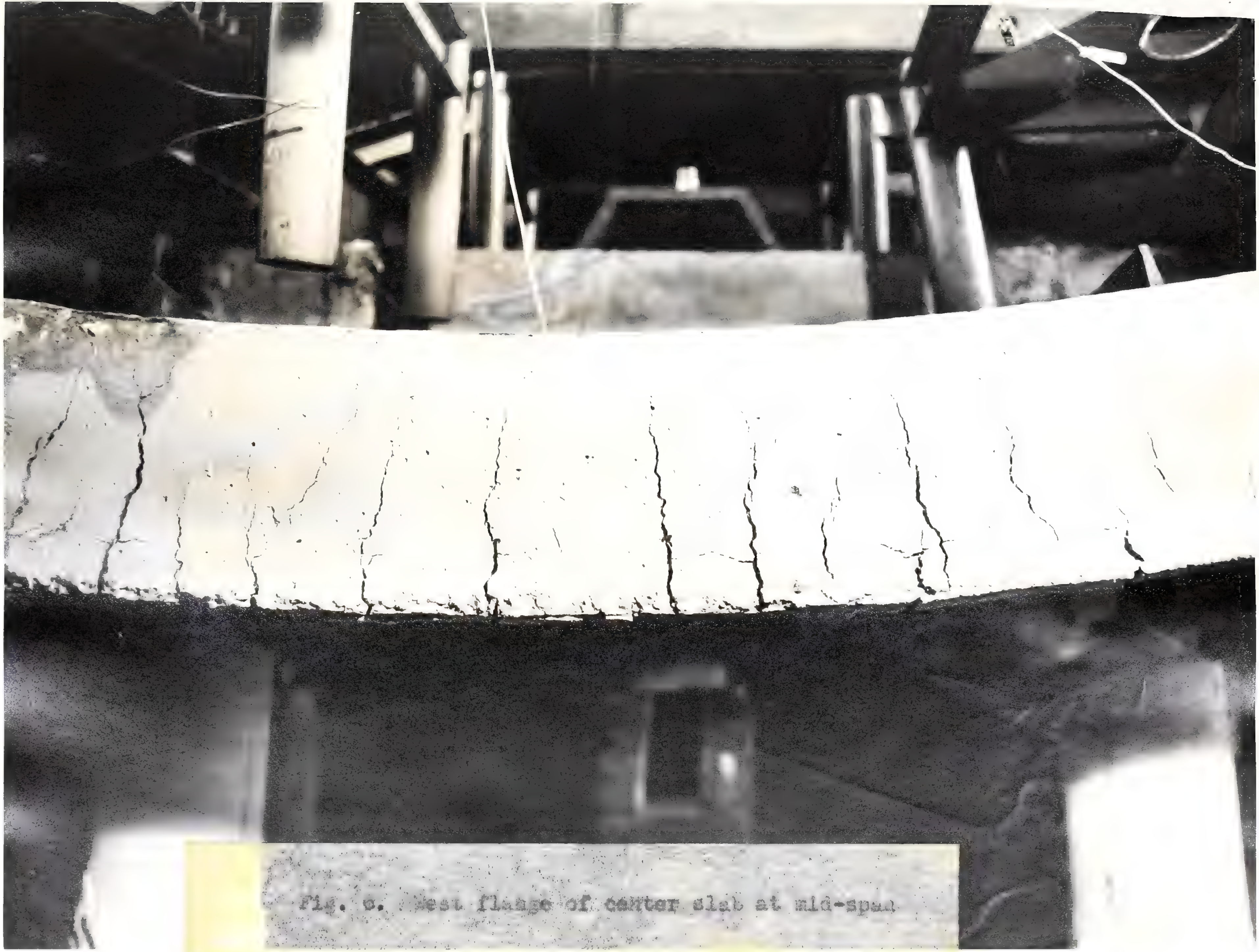

Fig. 6. West flange of center slab at mid-span

Fig. 7. North end of center slab, exposed face

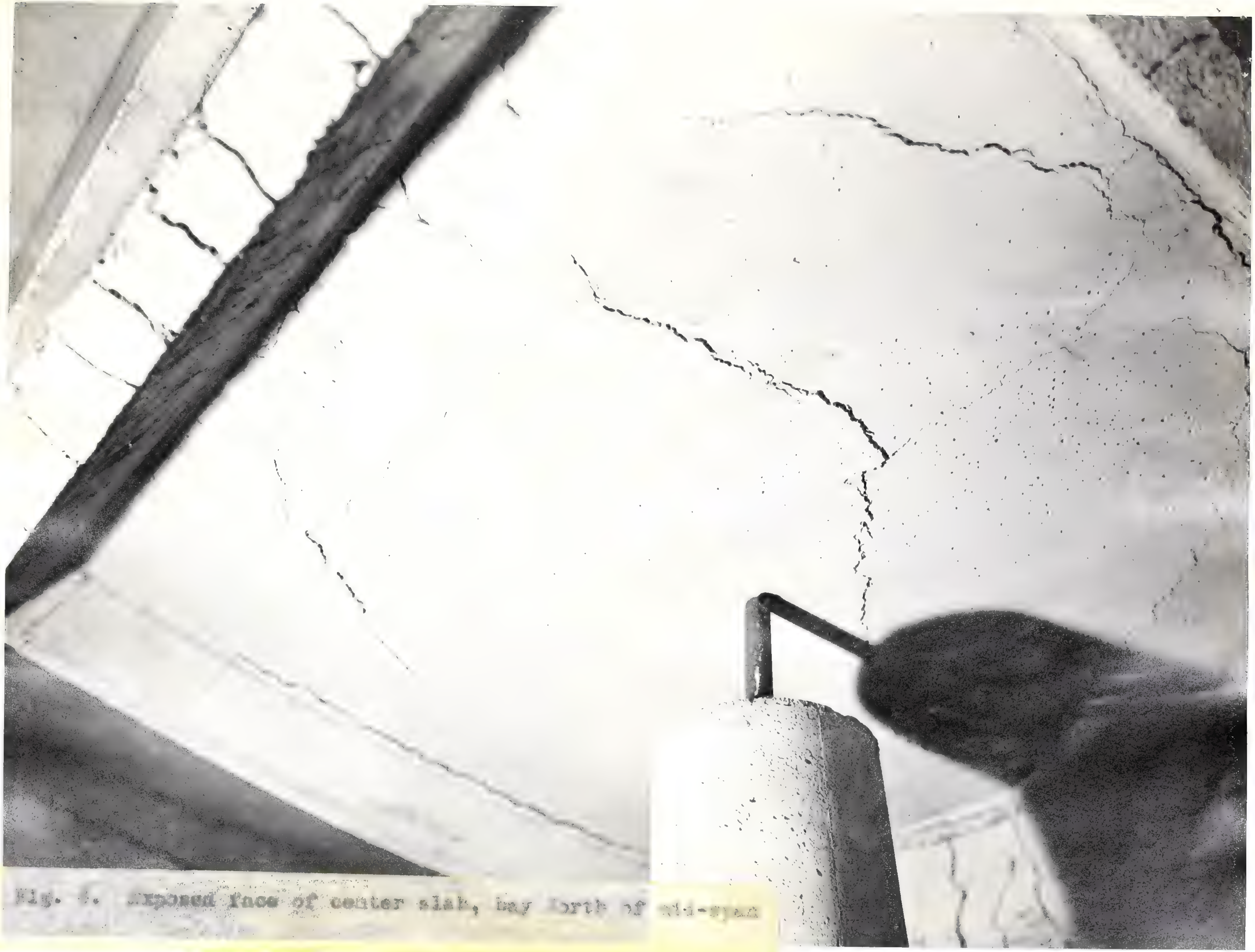

Fig. [illegible]. Exposed face of center slab, bay north of mid-span

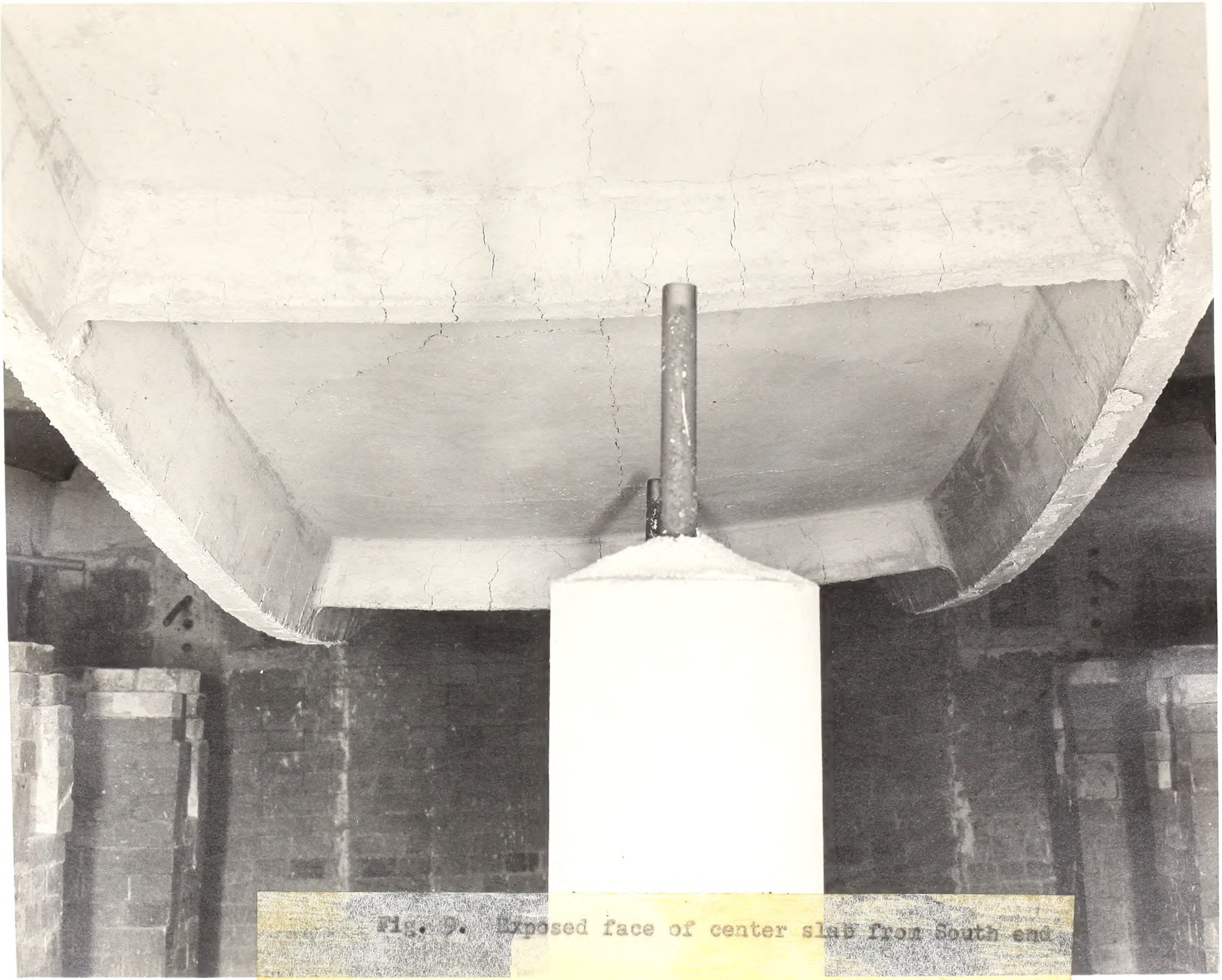

Fig. 9. Exposed face of center slab from South end